Genitourinary System
Imaging-Based Overview of Anatomy and Embryology

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Objectives

• Review *very high-yield* concepts
  – Anatomy test + USMLE Step 1

• GU Embryology
  – How it relates directly to common pathology

• Radiographic imaging
  – Brief overview of normal and abnormal findings
Overview

• 2 Main topics:
  – Urinary system
  – Reproductive system

• Both develop from the intermediate mesoderm

• Excretory ducts of both systems → cloaca
Part One:

URINARY SYSTEM
Pronephros

- 4th week
- Cranial to caudal
- Nephrotomes
- Forms and regresses within 1 week
- Mesonephros developing

Mesonephros

- **Glomerulus at medial end**
- **Bowman’s capsule** around glomerulus
- **Mesonephric duct** laterally
- **Urogenital ridge**
- **Gonadal ridge**
- Disappears by 2\textsuperscript{nd} month in females
- Partially remains in males to form genital system

TW Sadler, Langman’s Medical Embryology 9\textsuperscript{th} Edition, 2004
Metanephros

- Permanent kidney
- 5th week
- **Metanephros** = Glomerulus to distal convoluted tubule
- **Ureteric bud** = collecting ducts, major/minor calyces, renal pelvis, and ureter

Molecular Regulation

- Epithelial-Mesenchymal interactions
  - Epithelium of the ureteric bud from the mesonephros interacts with the mesenchyme of the metanephric blastema

- Complex two-way signaling process of reciprocal induction.

Ureters

- Retroperitoneal
- Crosses posteriorly to gonadal vessels
- Crosses bifurcation of the common iliac art.
- **Obstruction points:**
  - Ureteropelvic jnct.
  - Pelvic brim over distal end of common iliac
  - Ureterovesicular jnct.
Kidney-Ureter-Bladder (KUB)
CT Urogram: Non-contrast
CT Urogram: Corticomedullary Phase
CT Urogram: Nephrographic Phase
CT Urogram: Excretory Phase
CT Urogram: Excretory Phase

ajronline.org

radiographics.rsna.org
MPR and 3D Reconstructions
MPR and 3D Reconstructions

http://www.pvss.org/uploads/abstract_image_1907.jpg
CT Angiogram
Renal Ultrasound
What's Abnormal?

Wilms Tumor

- Typically in children
- Mutation in WT1 gene on chromosome 11
- Defect in reciprocal induction system
- WAGR syndrome:
  - Aniridia
  - Hemihypertrophy
  - Wilm’s tumor

http://www.pitt.edu/~super1/lecture/lec29961/018.htm
http://www.orthobullets.com/pediatrics/4044/hemihypertrophy
http://www.szote.u-szeged.hu/radio/retr/aret4c.htm
Potter’s Sequence

- Malformation of the ureteric bud
- Bilateral renal agenesis
- Oligohydramnios
- Limb deformities
- Facial deformities
- Pulmonary hypoplasia

http://prepgmedicos.redstetho.com/forum/viewtopic.php?f=89&t=7499
http://www.fetalultrasound.com/online/text/9-005.htm
What’s Abnormal?
Position of Kidney

What's Abnormal?
What’s Abnormal?
Horseshoe Kidney

Which vascular structure would prevent its ascent into the abdomen?

http://radiographics.rsna.org/content/24/2/453.full
Horseshoe Kidney

http://radiographics.rsna.org/content/24/2/453.full
Division of the Cloaca

5th Week

7th Week

8th Week

Urogenital Sinus

A - Undifferentiated
- Allantois
- Pelvic part of urogenital sinus
- Definitive urogenital sinus
- Urinary bladder
- Ureter
- Seminal vesicle
- Anorectal canal

B - Male
- Urachus
- Prostate gland
- Seminal vesicle
- Ductus deferens
- Penile urethra
- Prostatic and membranous urethra

Urethra

- Urethral epithelium from endoderm
- Everything else is splanchnic mesoderm
- Proliferation of the prostatic urethra in 3rd month
  - Male: prostate gland
  - Female: urethral and paraurethral glands

Bladder Defects

- **Urachal fistula**: persistent allantois
  - Urine drains from umbilicus
- **Urachal cyst**: Part of allantois persists and secretes fluid resulting in cystic dilation

http://radiographics.rsna.org/content/21/2/451.full
Bladder Defects

http://radiographics.rsna.org/content/21/2/451.full
Bladder Defects

http://radiographics.rsna.org/content/21/2/451.full
Bladder Defects

- **Bladder extrophy:** ventral body wall defect in which the bladder mucosa is exposed

Part Two:

REPRODUCTIVE SYSTEM
Gonads

- No M/F distinction till week 7
- **Genital ridge**: epithelium and mesenchyme
- Germ cells in ridge around week 6

Primordial Germ Cell Migration

- Travel: yolk sack (wk 3) → genital ridges (wk 6)
- Gonads only develop if cells arrive (induction)
- **Primitive sex cords** form prior to arrival of cells

Influence of Primordial Germ Cells

- 44 + XY
  - Y influence
  - Indifferent
  - Testis
    - Medullary cords develop
    - No cortical cords
    - Thick tunica albuginea
Testis Development

- **Testis Cords**: form from primitive sex cords
- **Rete Testis**: at hilum of gland
- **Tunica albuginea**: thickens to separate testis cords from surface epithelium
- **Sertoli cells**: derived from surface epithelium and lie between testis cords
- **Interstitial cells of Leydig**
  - Produce testosterone

http://www.ncbi.nlm.nih.gov/books/NBK9967/
Influence of Primordial Germ Cells

- 44 + XY
  - Y influence
    - Indifferent
      - Testis
        - Medullary cords develop
          - No cortical cords
            - Thick tunica albuginea

Influence of Primordial Germ Cells

44 + XX

Absence of Y

Primary gonad

Ovary

Medullary cords degenerate

Cortical cords develop

No tunica albuginea

Ovary Development

- Primitive sex cords replaced by vascular stroma
- Surface epithelium proliferates to form **cortical sex cords**
- Sex cords → cell clusters (4 mo)
- Primitive germ cells develop into **oogonia** (5 mo)
- Epithelial cells → **follicular cells**

http://www.ncbi.nlm.nih.gov/books/NBK9967/
Genital Duct Development

Testis
- Mullerian inhibiting substance (Sertoli cells)
- Testosterone (Leydig cells)
- Mesonephric ducts stimulated (vas deferens, epididymis)
- Dihydrotestosterone
- External genitalia stimulated
  Growth of penis, scrotum, and prostate
- Paramecensphenic ducts suppressed

Ovary
- Estrogens (including maternal and placental sources)
- Paramecensphenic ducts stimulated (uterine tube, uterus, upper portion of vagina)
- External genitalia stimulated (labia, clitoris, lower portion of vagina)

http://www.shoreline.edu/kwennstrom/internalgenitalia.jpg
Internal Genitalia at Glance
What you should know!
What’s Abnormal?

http://www.sciencephoto.com/media/294892/enlarge
Uterine and Upper Vaginal Duplications
Uterine and Upper Vaginal Duplications
External Genitalia Development

Male: *Dihydrotestosterone*
- Genital tubercle becomes the glans penis
- Urethral folds become the phallus
- Labioscrotal swellings become the scrotum.

Female: *Estrogen*
- Genital tubercle becomes the clitoris
- Urethral folds become the labia minora
- Labioscrotal swellings become the labia majora

http://www.tarleton.edu/Departments/anatomy/development.html
Defects in Male Genitalia

Hypospadias:
- Failure of urethral folds to close

Epispadias:
- Faulty positioning of genital tubercle
- Associated with bladder exstrophy

http://newborns.stanford.edu/PhotoGallery/Epispadias2.html
http://www.mayoclinic.com/health/medical/IM01071
Descent of Testes

- **Gubernaculum** attached at caudal pole of testis
- Factors controlling descent:
  - Increased intra-abdo pressure
  - Shortening of gubernaculum
- Deep & superficial **inguinal rings**
- **Processus vaginalis**
- Inguinal canal allows passage into scrotum

http://qs1252.pair.com/monarchm/elsevier/drake2e_v1/module71/popup/71_22_02.htm
Some Damn Englishmen Call It Testes

Skin, Dartos, External spermatic fascia, Cremaster muscle, Internal spermatic fascia, Tunica vaginalis

Layers of Testis

http://www.meddean.luc.edu
Clinical Correlates

- **Indirect inguinal hernia**: lateral to IE artery
  - Failure of processus vaginalis to close
  - Intestines pass through both rings into scrotum
  - Usually seen in male infants

- **Direct inguinal hernia**: medial to IE artery
  - Intestines pass directly through abdominal wall
  - Through superficial inguinal ring only
  - Covered by external spermatic fascia

- **Hydrocele**: Processus vaginalis open, cysts form, cysts secrete fluid that builds up
Clinical Correlates
Questions?

**Med School Advice:**

- Buy a copy of *First-Aid for USMLE Step 1* now → learn over two-year period
- Read *Apps of Steel* by Donna Magid (www.TeamRads.com) and plan ahead
- Use *Vertical Advisory*: Deans, College Advisors/Dr. Magid, and other students
- Have fun in med school...the time flies by!